Rec. zool. Surv. India: Vol. 122(1)/17- 23, 2022
DOI: 10.26515/rzsi/v122/i1/2022/167154

ISSN (Online) : 2581-8686
ISSN (Print) : 0375-1511

Distribution and roosting ecology of the lesser mouse-tailed bat, *Rhinopoma hardwickii* Gray, 1831 (Chiroptera: Rhinopomatidae)

Vadamalai Elangovan

Department of Zoology, School of Life Sciences, Babasaheb Bhimrao Ambedkar University, Lucknow – 226025, Uttar Pradesh, India; elango70@yahoo.com

Abstract

The mouse-tailed bats belong to family Rhinopomatidae face serious threat due to habitat destruction. A study on distribution, roost selection and reproductive behaviour of the lesser mouse-tailed bat, *Rhinopoma hardwickii* (Gray, 1831) was carried out in Uttar Pradesh as the state holds good number of historical monuments and natural caves suitable for survival of *R. hardwickii*. The individuals of *R. hardwickii* were characterized by long free tail, well developed muzzle like snout of pig, connected ear pinnae and hairless lower abdomen. The distribution of *R. hardwickii* was observed in dry and rocky regions of Uttar Pradesh. The roosts of *R. hardwickii* found in historical monuments, abandoned buildings and natural caves. The average temperature (29.8 ± 2.0 °C) and relative humidity (63.6 ± 4.2 %) did not fluctuate among the roosts. The colony size was ranged from 120 to 930 individuals. The bats occupied the surface of wall and attics solitarily during summer and clustered during winter. *Rhinopoma hardwickii* shared roost with *R. microphyllum* (Brunnich, 1782), *Taphozous nudiventris* (Cretzschmar, 1826) and *Hipposideros fulvus* (Gray, 1838). The individuals of *R. hardwickii* undergone mating during February-March and the gravid females gave birth during June-July. The study suggests that *R. hardwickii* preferred arid region wherein monuments, abandoned buildings and natural caves abundant, as they offer suitable conditions and reduced disturbance for their survival. Thus, the monuments which harbour *R. hardwickii* need to be protected without much renovation and human disturbances.

Keywords: Bundelkhand Region, Distribution, Mouse-Tailed Bats, Population Dynamics, Reproduction, *Rhinopoma hardwickii*, Roost Selection

Introduction

Bats make a significant contribution to the mammalian diversity and play vital ecological roles. The mouse-tailed bats belong to the family Rhinopomatidae, contain a single genus *Rhinopoma* and distributed in arid and semi-arid regions of southern Asia, northern Africa and Arabian Peninsula (Sinha, 1980; Koopman, 1993; Van Cakenberghe & De Vree, 1994; Benda *et al*., 2009; Carpenter *et al*., 2014). There are four known species of rhinopomatid bats (Qumsiyeh & Jones, 1986; Schlitter & Qumsiyeh, 1996), namely the lesser mouse-tailed bat, *Rhinopoma hardwickii* (Gray, 1831), the greater mouse-tailed bat, *Rhinopoma microphyllum* (Brunnich, 1782), the small mouse-tailed bat, *Rhinopoma muscatellum* (Thomas, 1903) and macinnes's mouse-tailed bat, *R. macinnesi* (Hayman, 1937). Among all species, *R. hardwickii* distributed widely in India (Sinha, 1980, 1981, 1986; Habersetzer, 1981; Bates and Harrison, 1997) and its subspecies distributed in Jordan, Sahara, Egypt, Libya, the Sudan, Arabia, Iran, Afghanistan, and Pakistan (Sinha, 1980; Qumsiyeh *et al*., 1998). The distribution of subspecies *R. hardwickii* was reported from Delhi, Uttar Pradesh, Rajasthan, Gujarat, Madhya Pradesh, Bihar, West Bengal, Karnataka, Andhra Pradesh, Maharashtra and Kerala (Sinha, 1980 & 1986; Saikia, 2018).

Earlier studies suggest that *R. hardwickii* preferably roost in natural caves, monuments, abandoned buildings and tunnels (e.g. Prakash, 1961; Sinha, 1980; Habersetzer, 1981; Pradhan, 2006; Srinivasulu *et al*., 2005; Purohit *et al*., 2006; Srinivasulu and Srinivasulu, 2017). Although, the

Article Received on: 23.11.2021 Accepted on: 15.02.2022

occurrence of *R. hardwickii* was reported in Uttar Pradesh (Sinha, 1980) and also the state has most suitable habitats (e.g. dry and semi-arid regions) and roost sites (e.g. caves, historical monuments and abandoned buildings), but a thorough study was lacking on distribution, roost selection and roosting behaviour of *R. hardwickii*. Therefore, a comprehensive study was carried out on distribution, roosting ecology, population dynamics and reproductive behaviour of the lesser mouse-tailed bat, *Rhinopoma hardwickii* in Uttar Pradesh.

Materials and Methods

Study area and roost survey

The state Uttar Pradesh culturally rich and consists good number of historical monuments. The Bundelkhand region of Uttar Pradesh is naturally dry and semi-arid zone with natural caves and monuments. Thus, the field surveys were carried out at historical monuments, old temples, abandoned buildings, caves and crevices to locate the roost sites of *R. hardwickii* at different districts, namely Allahabad, Firozabad, Agra, Mathura, Chitrakoot, Banda, Kanpur, Lucknow, Etawah, Mau, Barabanki, Mahoba, Lalitpur, Jhansi, Jaunpur, Sultanpur, Raebareli, Unnao, Faizabad, Fatehpur, Etah and Mirzapur.

Morphometry and species recognition

Bats were captured using hoop nets at their roost sites for species recognition and they were released at the site of capture after taking morphological measurements. The morphological parameters such as body mass (g), head and body length (HB), lengths of tail (T), ear (E), tragus (T), forearm (FA), 5th metacarpal (5MET), first phalanx of fifth metacarpal (1ph5mt), second phalanx of fifth metacarpal (2ph5mt), 4th metacarpal (4MET), first phalanx of fourth metacarpal (1ph4mt), second phalanx of fourth metacarpal (2ph4mt), 3rd metacarpal (3MET), first phalanx of third metacarpal (1ph3mt), second phalanx of third metacarpal (2ph3mt), 2nd metacarpal (2 MET), thumb, tibia (TIB), hindfoot (HF), length of maxillary tooth-row (C-M) and length of mandibular tooth-row (C-Mn) were measured using digital Vernier calipers (Mitutoyo, Japan) at 0.01 mm accuracy. The body mass of bats was measured using a digital balance (AVINET, USA) and wing span (WS) of fully stretched wings was measured.

Roost characteristics and roosting behaviour

The location of roost sites of *R. hardwickii* were precisely recorded using a handheld GPS (Montana 680, Garmin). The roost characteristics such as roost area (square feet), roost height (feet), roost temperature (°C) and humidity (%) were assessed and recorded. Light intensity at roost site was measured using a lux meter (KMLUX-99, Kusam). The colony size of *R. hardwickii* was assessed by visual count. The behaviours of bats at roosts were observed using night vision binocular (RM-99, Fieldking Optics). The reproductive status of bats was assessed based on body size, palpable embryo, large nipple and presence of pups.

Results

The lesser mouse-tailed bat, *Rhinopoma hardwickii* had a long free tail (66.0 ± 6.37 mm, n = 51) which was longer than its head and body length (64.2 ± 4.1 mm, n = 51). The average length of forearm (59.3 ± 3.0 mm, n = 51) was shorter than tail length. The morphological features of *R. hardwickii* obtained in the present and previous studies given in Table 1. The dermal ridge of the muzzle was well developed and appeared like the snout of pig (Figure 1). The ear pinnae were connected with a membrane at forehead and a circular shallow pit found at forehead. The lower abdomen was hairless during the winter season and looked like a fatty tissue (Figure 2).

The distribution of *R. hardwickii* was observed mainly in dry and rocky areas of Uttar Pradesh.

The distribution of *R. hardwickii* was observed in 18 districts of Uttar Pradesh, viz. Agra, Allahabad, Banda, Chitrakoot, Etah, Faizabad, Fatehpur, Firozabad, Jaunpur, Jhansi, Lalitpur, Lucknow, Mahowa, Mirzapur, Prayagraj, Raebareli, Sultanpur and Unnao (Figure 3). The colonies of *R. hardwickii* were observed in historical monuments, abandoned buildings, caves, mosques and temples. Nine of 21 colonies found in historical monuments and rests of them found in abandoned buildings, cave, temple and mosque. The roosts of *R. hardwickii* were observed in dark rooms, mostly in basements of monuments and abandoned buildings. The roosts located at Edalpur village in Firozabad and at Kakori in Lucknow were closest to water bodies. The average roost height was 15 ± 7.4 feet (n = 15) from the ground and surface area of roost was 184.6 ± 60.4 square feet (n = 15). The roost temperature

Table 1. The morphological characteristics of lesser mouse-tailed bat, *Rhinopoma hardwickii* obtained in the present study and the corresponding values of previous studies (Sinha, 1980; Bates and Harrison, 1997)

Morphological characteristics	*R. hardwickii* **(n = 51) (Mean ± SD)**	**Sinha (1980)**
Body mass (g)	24.30 ± 6.05	–
Head & Body length (HB)	64.29 ± 4.14	57 – 70
Tail length (T)	66.78 ± 6.37	60 – 81
Ear length (E)	16.08 ± 1.46	18 – 21
Tragus length (T)	06.25 ± 0.67	6 – 8
Forearm length (FA)	59.38 ± 3.05	58 – 64
5^{th} metacarpal (5MET)	41.23 ± 3.42	–
First phalanx of 5^{th} metacarpal (1ph5mt)	10.04 ± 0.74	–
Second phalanx of 5^{th} metacarpal (2ph5mt)	09.04 ± 0.92	–
4^{th} metacarpal (4MET)	36.09 ± 3.02	–
First phalanx of 4^{th} metacarpal (1ph4mt)	12.00 ± 0.96	–
Second phalanx of 4^{th} metacarpal (2ph4mt)	10.32 ± 0.69	–
3^{rd} Metacarpal (3MET)	42.57 ± 2.51	–
First phalanx of 3^{rd} metacarpal (1ph3mt)	08.34 ± 0.91	–
Second phalanx of 3^{rd} metacarpal (2ph3mt)	16.72 ± 1.11	–
2^{nd} Metacarpal (2 MET)	42.06 ± 2.83	–
Wing span (WSP)	298.2 ± 14.17	270 – 320
Thumb length	06.84 ± 1.05	–
Length of tibia (TIB)	28.82 ± 4.58	26 – 33
Hindfoot length (HF)	12.49 ± 2.70	13 – 17
C-M^n (Maxillary tooth-row)	06.64 ± 0.71	–
C-M_n (Mandibular tooth-row)	06.92 ± 0.87	–

Figure 1. The lesser mouse-tailed bat, *Rhinopoma hardwickii*.

Figure 2. The fatty abdominal tissue of *Rhinopoma hardwickii*.

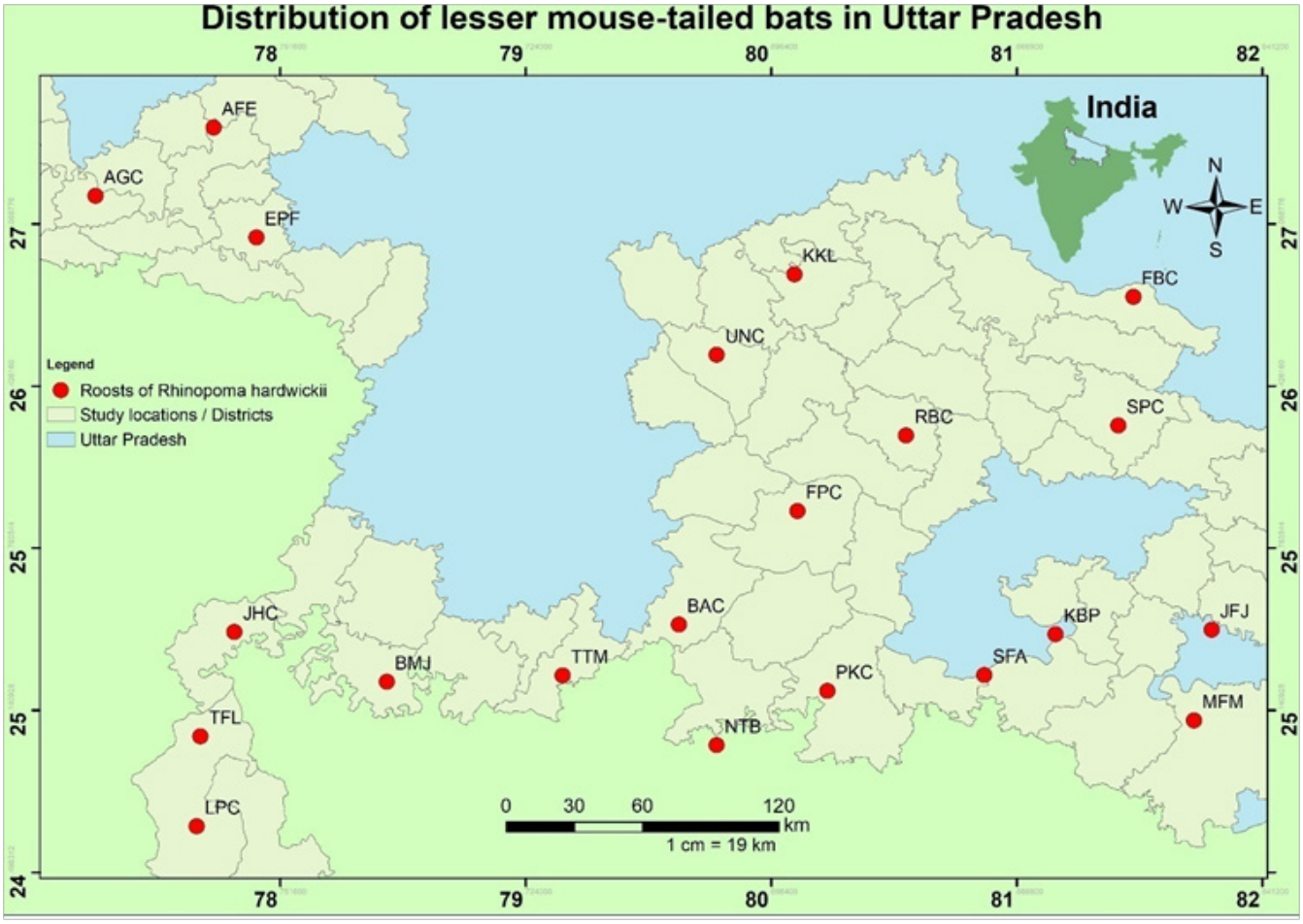

Figure 3. Map shows the distribution of lesser mouse-tailed bat, *Rhinopoma hardwickii*. The locations of roost sites were abbreviated and shown in the map: 1) AGC – Agra, 2) SFA – Sangam Fort (Allahabad), 3) NTB – Neelkanth Temple Kalinjar (Banda), 4) BAC – Banda, 5) PKC – Purani kotwali (Chitrakoot), 6) AFE – Awagdh Fort (Etah), 7) FBC – Faizabad, 8) FPC – Fatehpur, 9) EPF – Edalpur (Firozabad), 10) JFJ– Jaunpur Fort (Jaunpur), 11) BMJ – Bukhara, Mauranipur (Jhansi), 12) JHC – Jhansi, 13) LPC – Lalitpur, 14) TFL – Talbahte Fort (Lalitpur), 15) KKL – Kakori (Lucknow), 16) TTM– Tirthankar Temple (Mahowa), 17) MFM – Mirzapur Fort (Mirzapur), 18) KBP – Khusaroo bagh, 19) RBC – Raebareli, 20) SPC – Sultanpur, 21) UNC – Unnao.

(29.8 ± 2.0 °C) and relative humidity (63.6 ± 4.2 %) did not fluctuate among the roosts. The average intensity of light at roost site was 0.23 ± 0.044 lux. The colony size of *R. hardwickii* ranged from 120 – 930 individuals, while the number of groups in colonies varied from 1 – 5. The colony size was fluctuated over the study period and they shifted their roosts seasonally. They roost on walls and attics solitarily during summer, while they aggregate as clusters during winter. The bats occupied the wall surface and moved often quadrupedally to adjust themselves. They moved to crevices and holes when they were disturbed. The general behaviours such as tail wagging, scanning, grooming, roost shifting, and wing stretching were observed at roosts. *Rhinopoma hardwickii* shared the roost with *R. microphyllum*, *Taphozous nudiventris* and *Hipposideros fulvus*. Annual reproductive cycle was observed in *R. hardwickii*. The individuals undergone mating between February and March, and the gravid females gave birth between June and July. The pups began to fly independently and became volant at the end of August. The pups held the false teat of mothers while the latter hung upside down during nursing period.

Discussion

The results of present study show that the lesser mouse-tailed bat, *Rhinopoma hardwickii* distributed in South and central Uttar Pradesh as well as Bundelkhand region. The districts such as Allahabad, Firozabad, Agra, Mathura, Chitrakoot, Banda, Lucknow, Etah, Mahoba, Jhansi and Lalitpur hold good number of historical monuments and most suitable habitats for the survival of *R. hardwickii*. Further, the Bundelkhand region has vast agricultural fields and open grasslands which act as good foraging grounds for *R. hardwickii*. Thus, out of 22 districts surveyed in Uttar Pradesh, the monuments, abandoned buildings and caves of 18 districts harboured *R. hardwickii*. On earlier occasion, the rhinopomatid bats were observed at Fatehpur Sikri (Sinha, 1980), Agra (Brosset, 1962) and Pratapgarh (Khajuria, 1953) in Uttar Pradesh. Prakash (1961) found colonies of *R. hardwickii* in deserted palace, caves, temples, and tunnels in Jodhpur, Barmer, Jaisalmer and Bikaner in Rajasthan. In Bihar, *R. hardwickii* was observed in monuments, caves and discarded houses in hillock, and the colony size ranged approximately from 50 – 500 individuals (Sinha, 1980). *Rhinopoma hardwickii* was one of the most common species found in caves of Madurai region of South India and lived in large colonies along with *Megaderma lyra*, *Taphozous kachhensis*, and *H. bicolor* (Habersetzer, 1981).

In the present study, the mouse-tailed bats preferred to roost in wooden ceilings, natural caves, old and abandoned buildings. The observation showed that the bats selected the basement and rear rooms of abandoned buildings or monuments, since they fetch them less disturbance, low light intensity and high humidity. Further, the basement of many buildings had the wooden cladding on which the bats preferably occupied. Similar observations were made on roost selection and roosting behaviour of rhinopomatid bats (Schlitter and Qumsiyeh, 1996). The roost sharing behaviour observed in the present study was already reported on earlier occasions too. The mouse-tailed bats were cohabitated with *T. nudiventris* and *T. melanopogon* (Brosset, 1962), and *R. microphyllum (Schlitter* & Qumsiyeh, 1996). In the current study, *R. hardwickii* shared the roost sites with *R. microphyllum*, *Taphozous nudiventris* and *Hipposideros fulvus* and suggest the suitability of roosts, lack of conflicts on roost space and a niche segregation among different species.

The differences in roosting behaviour of *R. hardwickii* across seasons show that they regulate their body temperature by roosting clustered during winter and scattered during summer. The aggregation of bats as clusters during winter may reduce heat loss while scattered roosting during summer enhance airflow and space for wing fanning which reduce body temperature. The rhinopomatid bats may undergo winter torpor and draw energy from fat deposited in the abdominal region (Advani, 1981; Kumar, 1965). The moderate temperature, high humidity and less light intensity observed in the roosts of *R. hardwickii* were in adherence with the earlier observations by Khajuria (1979), in which *R. hardwickii* roosts had temperature range from 16.8 to 35.3 °C, relative humidity from 57 to 82 % and light intensity from 0.19 to 0.29 lux. Levin *et al.* (2015) reported that the subtropical mouse-tailed bats hibernate during winter while other bats were active.

The morphological measurements of *R. hardwickii* obtained in the present study were similar to the earlier studies (Sinha, 1980, 1981, 1986). The striking morphological feature of *R. hardwickii* was the longer tail length than the forearm, while it was shorter in *R. microphyllum*. The annual reproductive cycle of *R. hardwickii* observed in this study coincided with earlier observations (Kumar, 1965; Gaur & Shahrokh, 1989) and further the juvenile and volant stage coincided with the monsoon season wherein the food availability was abundant.

The roost site preference of *R. hardwickii* was carried out across the country and found decline in roost sites and thus the population size. A large colony of *R. hardwickii* observed in a historical monument located on a hillock and semi-arid region of the Thar Desert, however, the number of past roost sites drastically declined due to urbanization (Purohit *et al.*, 2006). Pradhan (2006) reported the distribution of lesser mouse-tailed bat near Tadoba rest house in Maharashtra; however, it was not locally common species. Korad (2014) studied the diversity of chiropteran fauna of Maharashtra, and found only one colony of *R. hardwickii* which contributed 0.2% of chiropteran distribution. It shows that the roost habitat requirements play a vital role in the distribution and population persistence of *R. hardwickii*.

Majority of studies revealed that the mouse-tailed bats prefer to roost in historical monuments, abandoned

buildings and natural caves. The present study has confirmed the distribution of the lesser mouse-tailed bat in basements and abandoned portions of monuments. However, the monuments are being renovated for public visits. As a result, the bats are forced to vacate their roosts and at times they were removed using fire or prevented by erecting nets. All these events are causes for destruction of roost sites as well as population reduction. Thus, more studies are required to assess the distribution and roost site selection across the country for proper conservation measures.

Acknowledgements

The Archaeological Survey of India is acknowledged for permitting the research team to conduct the field survey in historical monuments of Uttar Pradesh. The author thanks the active support of Mr. Yogesh Kushwaha, Dr. Pawan kr Misra, and Mr. Shakthivardhan Sing during field survey and data collection. The financial assistance of Science and Engineering Research Board, Department of Science and Technology, New Delhi through a major research project (No. EEQ/2018/000104) to VE is acknowledged.

References

Advani, R. 1981. Food and feeding ecology of the rat-tailed bat in the Rajasthan desert. *Acta Theriol.*, **26**:269-272. https://doi.org/10.4098/AT.arch.81-21

Bates, P.J.J. and Harrison, D.L. 1997. Bats of the Indian subcontinent. Harrison Zoological Museum Publication, Sevenoaks, Kent, pp. 1-258.

Benda, P., Reiter, A., Al-Jumaily, M., Nasher, A.K. and Hulva, P. 2009. A new species of mouse-tailed bat (Chiroptera: Rhinopomatidae: Rhinopoma) from Yemen. *J. Nat. Mus. Prague, Nat. Hist. Ser.,* **177**:53-68.

Brosset, A. 1962. The bats of central and western India. *J. Bombay nat. Hist. Soc.*, **59**:1-78.

Carpenter, J., Hegyeli, Z., Bugariu, S., and Moldován, I. 2014. First confirmed records of Lesser Mouse-tailed Bat, Rhinopoma cystops Thomas, 1903, for Sinai, Egypt (Mammalia: Chiroptera). *Zoology in the Middle East*, **60**:180-182. https://doi.org/10.1080/09397140.2014.914750

Gaur, B.S., and Shahrokh, M.G. 1989. Parental care in two insectivorous bats: *Rinopoma microphyllum* kinneari and *Taphozous perforatus*. *Bat Research News*, **30**:32-33.

Habersetzer, J. 1981. Adaptive Echolocation Sounds in the Bat *Rhinopoma hardwickei* a field study. *J. Comp. Physiol. A.*, **144**:559-566. https://doi.org/10.1007/BF01326841

Khajuria, H. 1953. Taxonomic studies on some Indian Chiroptera. *Rec. Ind. Mus.*, **50**:113-128.

Khajuria, H. 1979. Studies on bats (Chiroptera: Mammalia) of M.P. India, Part I (Families: Pteropidae, Rhinopomatidae and Embalonuridae). *Rec. Zool. Surv. Ind., Occ. Paper No.*, **13**:1-59.

Koopman, K.F. 1993. Order Chiroptera. In: Mammal species of the World: A taxonomic and geographic reference (Wilson, D.E. and Reeder, D.M. eds.). 2nd ed. Smithsonian Institution Press, Washington, D.C. Pp. 137-241.

Korad, V.S. 2014. Studies on diversity, distribution, and conservation of the bat fauna in Maharashtra State, India. *Taprobanica*, **6**(1):32-45. https://doi.org/10.4038/tapro.v6i1.7083

Kumar, A.T.C. 1965. Reproduction in rat-tailed bat *Rhinopoma kinneari*. *Zoology*, **147**:147-155. https://doi.org/10.1111/j.1469-7998.1965.tb04639.x

Levin, E., Plotnik, B., Amichai, E., Braulke, L.J., Landau, S., Yom-Tov, Y., and Kronfeld-Schor, N. 2015. Subtropical mouse-tailed bats use geothermally heated caves for winter hibernation. *Proc. Royal Soc. B.*, B282: 20142781. https://doi.org/10.1098/rspb.2014.2781 PMid:25740890 PMCid:PMC4375864

Pradhan, M.S. 2006 Mammalia. In: Fauna of Tadoba-Andhari Tiger Reserve (Maharashtra), *Conservation Area Series* (Ed. Director, Zoological Survey of India, Kolkata), **25**:11-63.

Prakash, I. 1961. Taxonomic and biological observations on the bats of the Rajasthan desert. *Rec. Ind. Mus.*, **59**:149-170.

Purohit, A., Vyas, K.B. and Senacha, K.R. 2006. Population dynamics of bats in and around Jodhpur of great Indian desert. *Tigerpaper*, **33**(3):15-22.

Qumsiyeh, M., Amr, Z. and Al-Oran, R. 1998. Further records of bats from Jordan and a Synopsis. *Turk. J. Zool.*, **22**:277-284.

Qumsiyeh, M.B. and Jones, J.K. 1986. *Rhinopoma hardwickii* and *Rhinopoma muscatellum- Mammalian Species*, **263**:1-5. https://doi.org/10.2307/3503821

Saikia, U. 2018. A review of chiropterological studies and a distributional list of the bat fauna of India. *Rec. Zool. Surv. Ind*., **118**(3):242-280. https://doi.org/10.26515/rzsi/v118/i3/2018/121056

Schlitter, D.A. and Qumsiyeh, M.B. 1996. *Rhinopoma microphyllum*. *Mammalian Species*, **542**:1-5. https://doi.org/10.2307/3504243

Sinha, Y.P. 1980. The bats of Rajasthan: taxonomy and zoogeography. *Rec. Zool. Surv. Ind*., **76**:7-63.

Sinha, Y.P. 1981. Studies on bats of Gujarat. *Rec. Zool. Surv. Ind*., **78**:101-112.

Sinha, Y.P. 1986. The bats of Bihar-taxonomy and ecology. *Rec. Zool. Surv. Ind*., **77**:1-72.

Srinivasulu, B. and Srinivasulu, C. 2017. A first record of three hitherto unreported species of bats from Kerala, India with a note on *Myotis peytoni* (Mammalia: Chiroptera: Vespertilionidae). *J. Threat. Taxa*., **9**(5):10216-10222. https://doi.org/10.11609/jott.3324.9.5.10216-10222

Srinivasulu, B., Srinivasulu, C. and Ravinder, B. 2005. Occurrence of Lesser Mouse-tailed Bat *Rhinopoma hardwickii* Gray, 1831 and Black-bearded Tomb Bat *Taphozous melanopogon* Temminck, 1841 (Mammalia: Chiropetra: Rhinopomatidae and Emballonuridae) in Adilabad district, A.P. *Bat Net*, **6**(2):2-3. https://doi.org/10.11609/JoTT.ZPJ.1306.1935-8

Van Cakenberghe, V. and De Vree, F. 1994. A revision of the Rhinopomatidae Dobson 1872, with the description of a new subspecies (Mammalia: Chiroptera). *Senckenbergiana Biologica*, **73**:1-24.